Test of direct pTP deposit on acrylic

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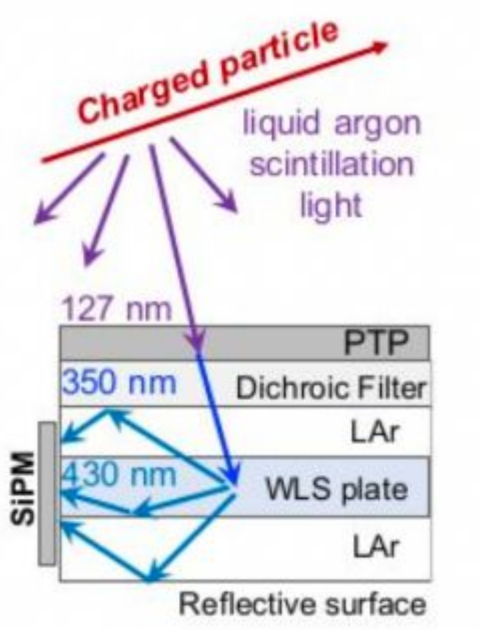
Photon detection system of the far detector (FD2) of the DUNE experiment



Not to scale

- The p-terphenyl (pTP) and the dichroic filter are coated on a glass substrate
- The pTP shifts the scintillation photons (127 nm) to a wavelength peaking at ~350 nm
- The acrylic doped with WLS shifts photons peaking at ~350 nm to ~ 430 nm
- The dichroic filter reflects photons above the wavelength cut-off 400 nm

Motivation

- Duration of the whole evaporation process for FD2 : 1 to 2 years [1]
- LArPDS from FD2 to FD3: convert TPC field cage structure into a fully active PDS [2]
    - Expand x10 optical coverage (wrt FD2 PDS)

    ⇒ need ~20 years for the evaporation process with the current method

- Preliminary measurement of FD2 X-ARAPUCA suggests removing the FD2-style dichroic filter could increase the PDE by 30% [3]
- A direct deposit of the pTP on the acrylic could accelerate this process and simplify the detector design

[1] https://indico.fnal.gov/event/65112/contributions/293825/attachments/178836/243937/EvaporatorNapoli_V2.pdf
[2] https://indico.fnal.gov/event/59908/contributions/267653/attachments/168279/225378/VD-Optimized-FD3-Intro-SBU-WS-June23.pdf
[3] https://indico.fnal.gov/event/64541/contributions/290384/attachments/177422/241543/DUNE_PDC_30_04_24.pdf

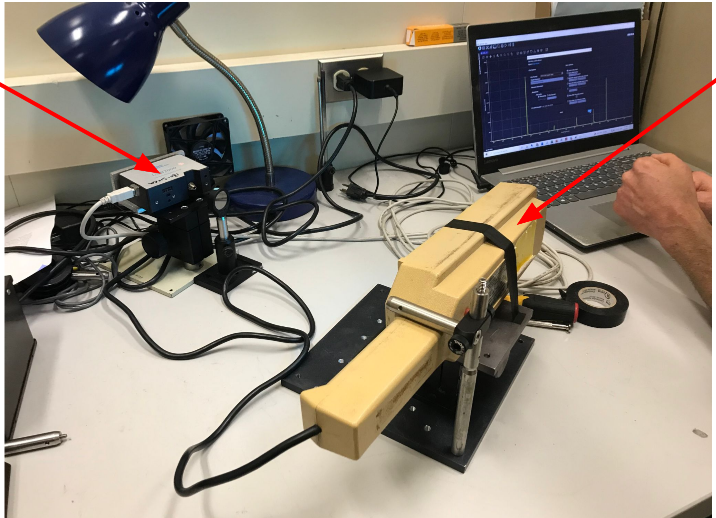
Method we use

Test on:

- Pure acrylic
- FD2 acrylic : Acrylic with WLS that shifts light from ~350 nm to ~430 nm

Method:

- Dissolve the p-terphenyl (pTP) powder in a solvent with methyl methacrylate (MMA) monomers
- Brush the solution on the acrylic slab and let it dry
- Perform the spectroscopy to get the transmission spectrum of the acrylic



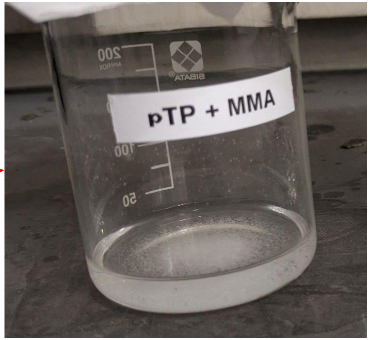
First sample - Procedure

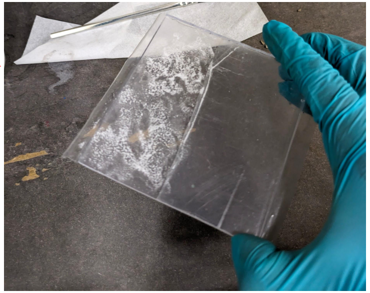
- Solvent: Methyl Methacrylate solution (MMA)

  ⇒ The MMA did not dissolve the pTP well

- Brushed the solution on a pure acrylic

- Brushed the solution on the FD2 acrylic

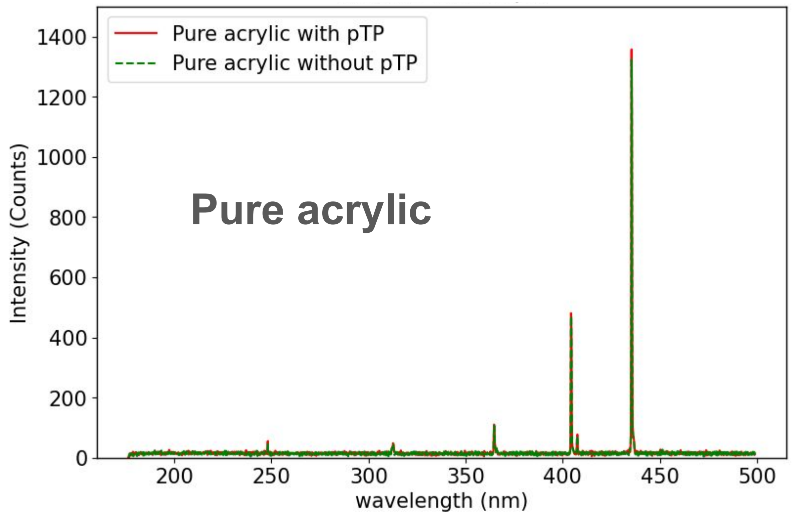


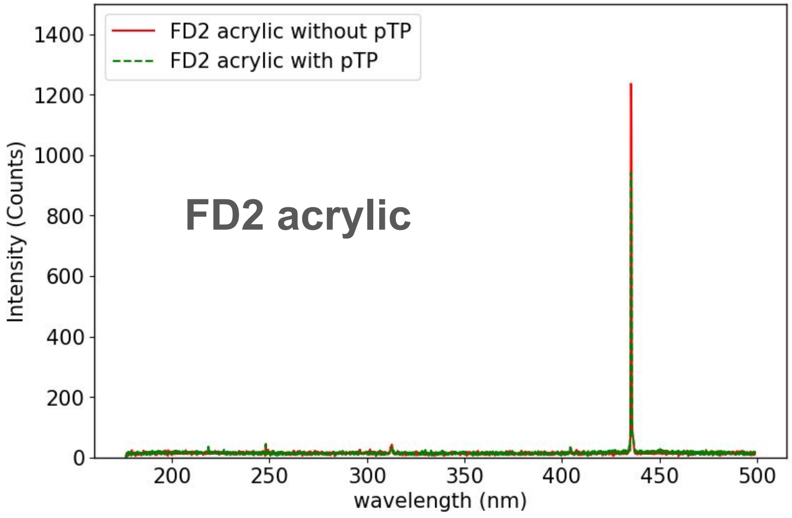


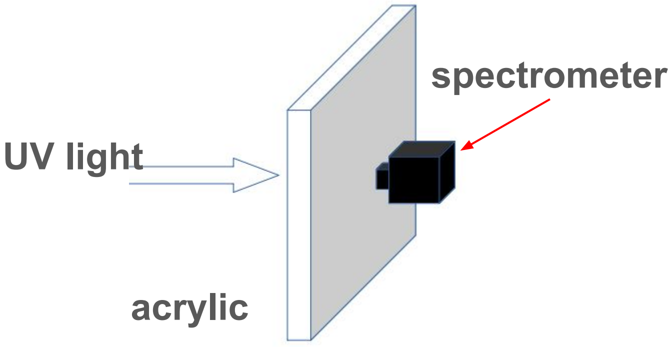
The pTP brushed off easily.

Some residue was still observed on the acrylic and we did the spectroscopy (next slide).

First sample - Spectroscopy



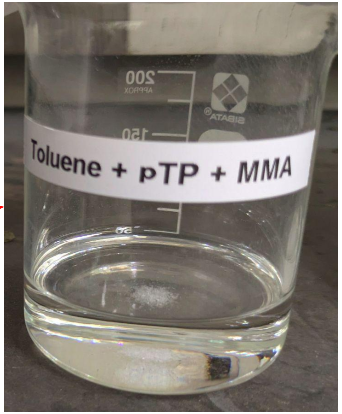




- Pure acrylic with and without pTP have the same spectrum
- FD2 acrylic with and without pTP have similar spectrum
- No evidence for shifted light is observed
  ⇒ pTP + MMA doesn’t work

Second sample - Procedure

- Solvent : Toluene
  - Dissolve the pTP in the toluene
  - Add MMA to the solution
- Brushed the solution on a pure acrylic and also the FD2 acrylic



⇒ Toluene dissolves the pTP better than MMA

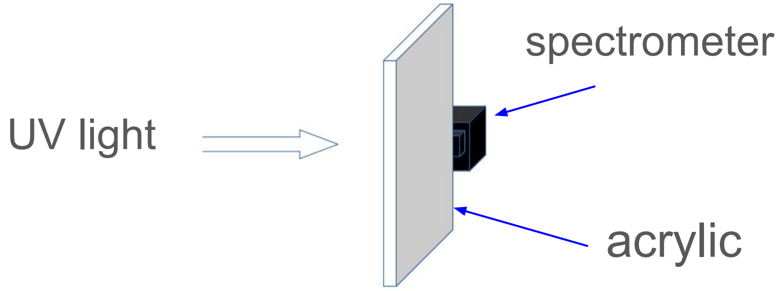
⇒ The pTP sticks better on the acrylic

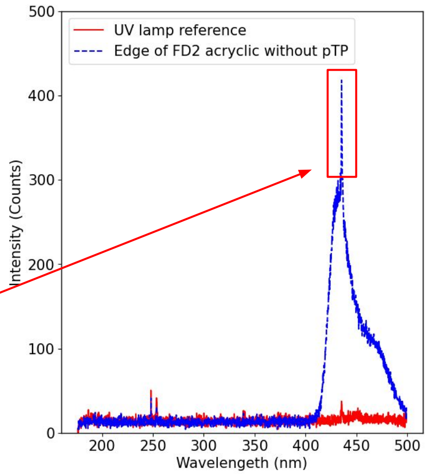
Second sample - Spectroscopy

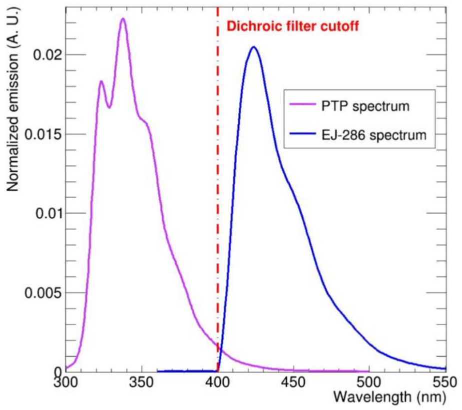
Spectrometer port perpendicular to incident light, on the edge of the acrylic

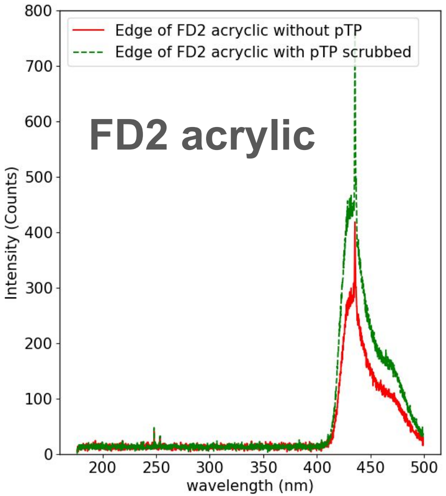
- Spectrum of FD2 acrylic without pTP similar to the one in the plot on the top right (EJ-286), except for the peak

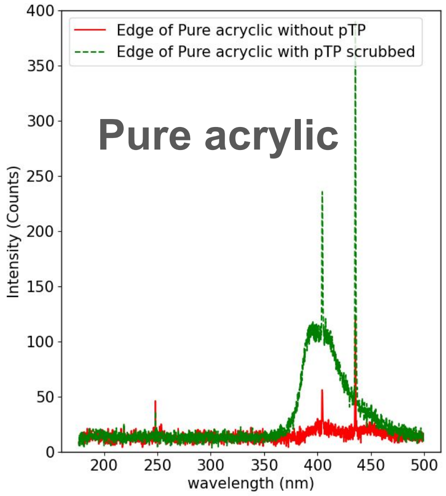
- Increase of the intensity in the range 400 nm to 500 nm for FD2 acrylic and 350 nm to 500 nm for pure acrylic





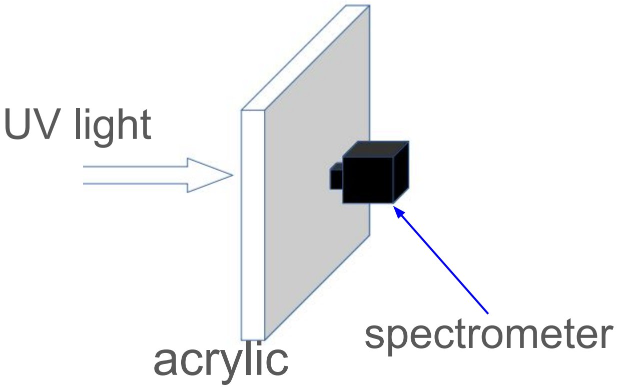




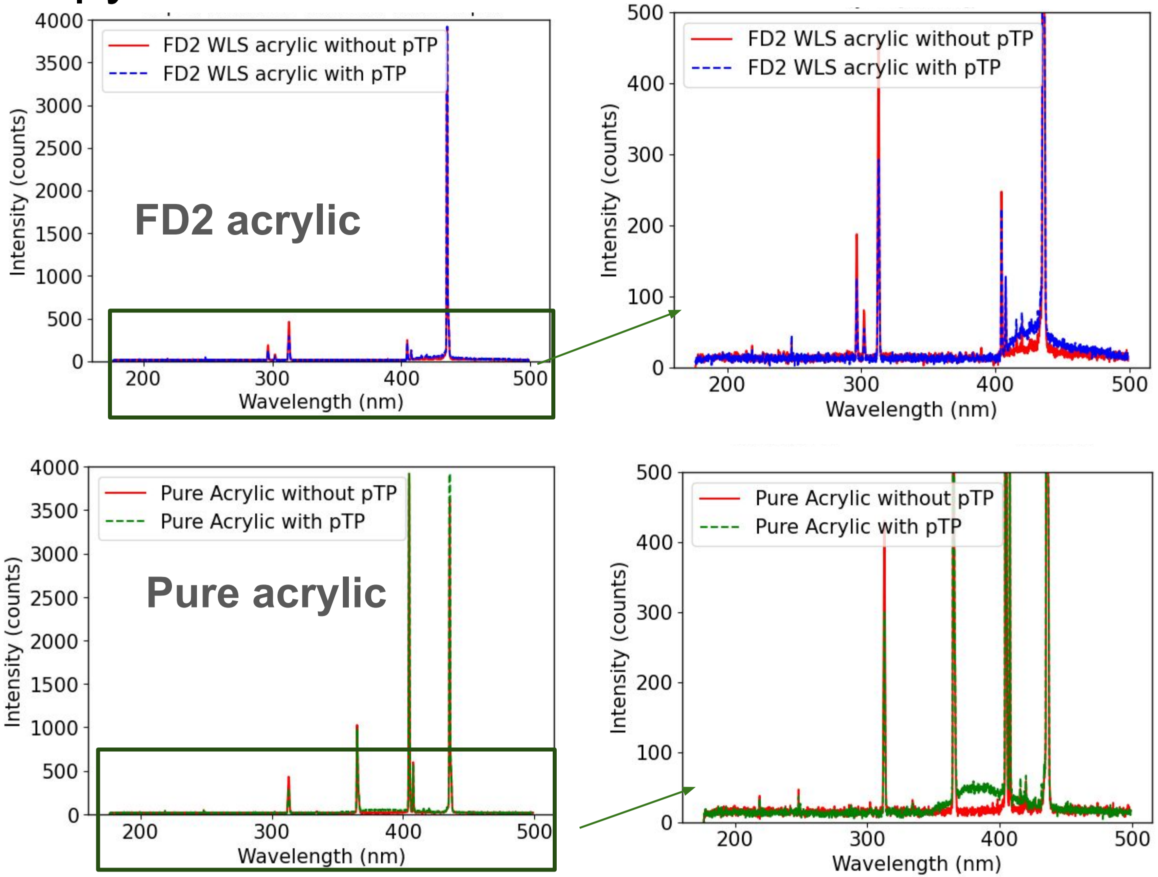


Second sample - Spectroscopy

Spectrometer port **facing** the incident light:



- Observation for acrylic with pTP
  - A small decrease of the intensity of light with wavelength < 350 nm
  - A bump for wavelength > 350 nm



Summary and next steps

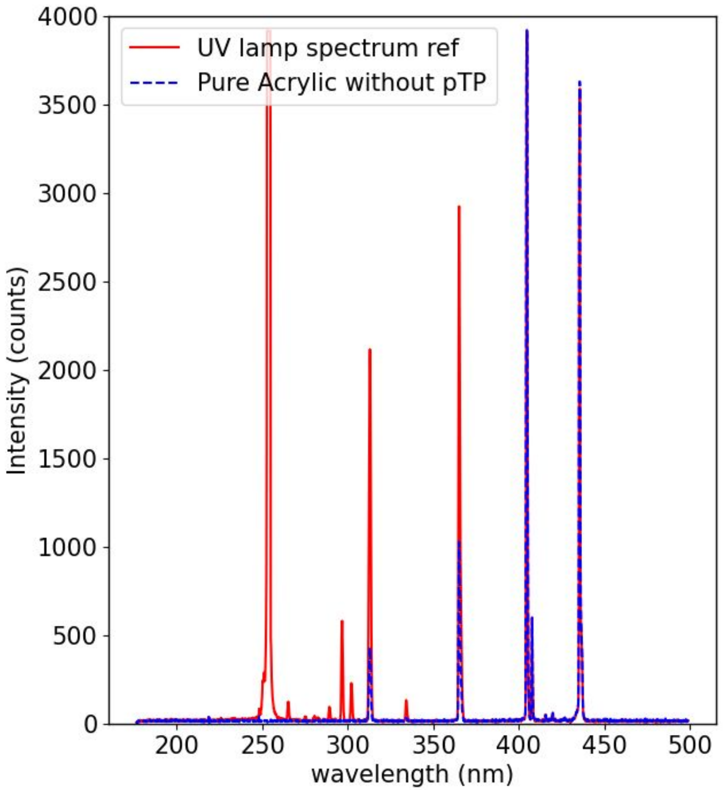
- Using toluene as a solvent to dissolve the pTP powder works better than directly dissolving it in MMA solution

- Next steps
  - Finding the best ratio of pTP that can be dissolved in the toluene and MMA
  - Proceed to cryogenic test (in LN2) to see how much of the pTP sticks to the acrylic after immersing it in LN2 ⇒ Do spectroscopy
  - Finding a better way to apply the solution to the acrylic for better uniformity and wavelength shifting

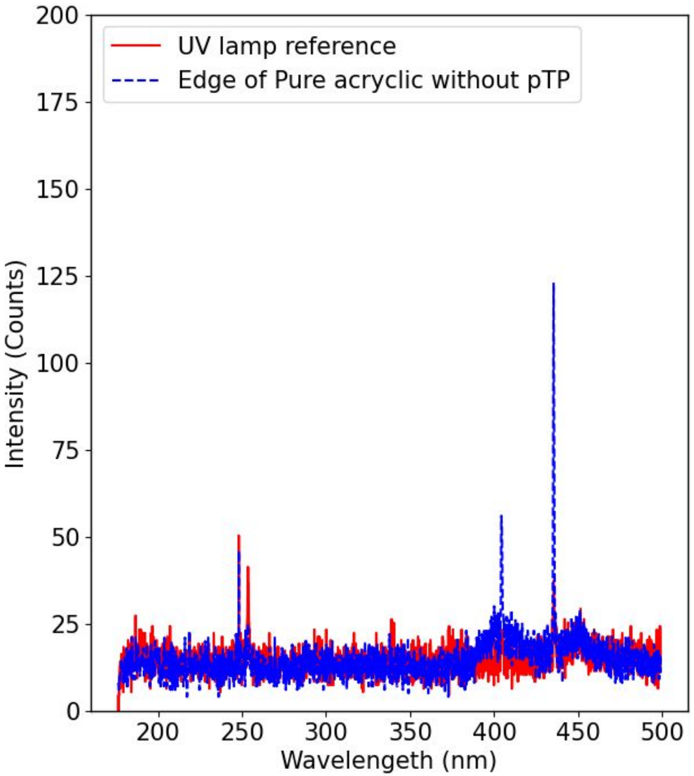
Backup

Spectrum of the Pure acrylic without pTP

Spectrometer facing the UV lamp

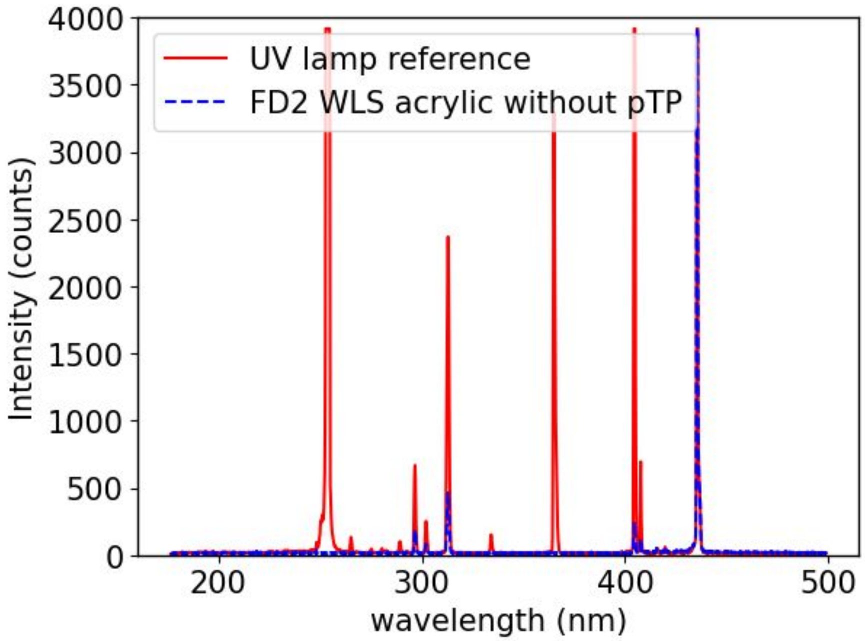


Spectrometer at the edge of the acrylic



Spectrum of the FD2 acrylic without pTP

Spectrometer facing the UV lamp



Spectrometer at the edge of the acrylic